FAST & SIMMS

Lighting Problems in the
University of Illinois Auditorium

Electrical Engineering

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LIGHTING PROBLEMS IN THE UNIVERSITY OF ILLINOIS AUDITORIUM

BY

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THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED LIGHTING PROBLEMS IN THE UNIVERSITY OF ILLINOIS AUDITORIUM

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

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LIGHTING PROBLEMS IN THE UNIVERSITY OF ILLINOIS AUDITORIUM

INTRODUCTION

The effective lighting of large interiors has received much attention recently. In addition to fulfilling the requirements of sufficient illumination, some attention should be paid to the decorative features possible with skillfully designed lighting. The illuminating engineer must endeavor to bring out the architectural features of the building to be lighted, or at least make the lighting harmonious with such features. It is a common principle of illumination to make the lighting subordinate like the background of a picture. In an assembly hall, there is the further necessity of so locating the light sources as to be out of the direct line of vision of the audience viewing the platform and if possible out of the view of the speaker upon the platform.

Recent revolutionary improvements in incandescent lamps by the introduction of lamps of higher efficiency using metalic filaments, make the problem of utilizing the new lamps worthy of study. We present the results of a careful investigation of the lighting problems of the University of Illinois Audtiorium in the following thesis: (a good print of the Auditorium is shown on page 32)

DESCRIPTION OF WIRING SYSTEM

The power for lighting the Auditorium is furnished

by the University power plant, by the two-phase 440 volt four wire system. Feeders are run from the main switchboard in the power plant through the underground tunnel and enter the Auditorium in the basement, then carried to a special transformer on the same floor.

The transformer room contains one marble switchboard on which are mounted the two single throw, double pole main line switches, which makes it possible to cut all the power from the building at this board. At the side of the board are mounted the two balancing coils, one for each phase.

The original plan called for a 220 volt two wire distribution, but the introduction of the metal filament lamp and its better adaptation to low voltage circuits has made it advisable to change the plans and wire the building for the new, more efficient lamp in order that they could be used as soon as they became a commercial success. For this purpose the middle points of the 220 volt coil were tapped giving four 110 volt circuits for distribution. These wires are carried to the switchboard and then branch out into the feeders for the separate switchboards located in the different parts of the building. These switchboards serve both as a distributing and switching board.

A very commendable feature of the wiring of the Auditorium is the careful balancing of the lighting load, and the symmetrical arrangement of the light switching. Instead of having one switch control one or more chandeliers, one switch controls one-half of the lights in all the dome chandeliers

so that they can be turned on with a minimum disturbance to the audience. The wiring for the lighting is so arranged that, no matter in what order the circuits may be opened, the lighting of the interior is maintained symmetrical.

The entrances are provided with gas jets which are lighted for every evening's intertainment. This precaution is a good one, for if, for some reason, the electric lights should fail, the building will not be left in total darkness and the chance of accident due to a panic is avoided.

GENERAL DISCUSSION OF PROBLEM

The system of lighting when our work began at the Auditorium was very satisfactory, as regards distribution of light, the amount being adequate for reading programs. Photometer tests showed an average of about .35 candle feet, reading as high as .4 and dropping to .13 in the most unfavorable positions of the main floor where seats are seldom occupied. In such a building as the Auditorium the lighting should be sufficient for reading a program in all parts of the room without any undue strain on the eyes. To accomplish this, an intensity of from .3 to .5 candle feet is required. Thus we see that from the consideration of adequate illumination the system was satisfactory, and were this all which is required of a system of lighting we would have hesitated to attempt any improvement. However, there are other things to be considered aside from good distribution of lighting.

The architectural features of the building must be studied and since the indirect lighting was deemed inadvis-

able, the best artistic effect must be secured. This does not mean that any beautiful, costly lighting fixture is appropriate regardless of its surroundings. A chandelier with cut glass reflectors and decorated with fine art glass tapestry is beautiful in itself, but would be quite out of place if located in the Auditorium. There every thing is strong and massive and the fine details of such a chandelier would be entirely at variance with such surroundings. In all the architectural outlines at the Auditorium, the theme is curved lines. The only straight lines found are the panels at the back of the stage, and we realize at a glance that these require no assistance for due emphasis. Every where are seen graceful curves and therefore it is necessary that the lighting fixtures be so chosen that this effect is carried out. We feel that here one mistake was made. The fixtures as we found them were supported by vertical brass rods of an unnecessary length. From the mainfloor, the fixtures supported from the dome were not so unsightly, but from the balcony they not only appeared inappropriate but actually brought the bare carbon lamps in the line of vision,- a mistake always to be avoided. If the fixtures are of necessity to hang so low, frosted bulbs should have been used.

A worse feature than this is the placing of the stage lights. This has been greatly magnified since the new painting by Millet has been placed in the arch above the stage. Even from the front seats on the mainfloor, one cannot view the painting with any degree of satisfaction, be-

cause it is obstructed by the vertical brass rods of the stage lighting fixtures. Some one has aptly expressed it thus, "The figures in the picture are made to appear as animals in a cage peering out between iron bars." The photographs on pages 34 and 35 give one an idea of their location relative to the picture. Fig. 1 shows them as they appear from the balcony, and Fig. 2 as they appear from the mainfloor. Aside from being an obstruction to the painting, the long vertical suspension rods are very unsightly. They not only emphasize the straight line paneling at the back of the stage, but destroy the curves so necessary to the beauty of the building. This painting has brought out more clearly another undesirable feature of the dome chandelier design. It will be seen in the accompanying photographs that these fixtures consist of a large brass sphere with brass arms which support the incandescent lamps. These arms, all being in the same horizontal plane, cut off part of the light. The result is that a heavy shadow is projected upon the walls of the room. This shadow, unfortunately, falls across one of the most delicate parts of the painting, a faintly tinted canopy floating in a background of blue, and makes it appear an indistinct mass lacking the life and beauty which is so necessary to it as the work of a master artist. The shadow effect could have been greatly lessened by suspending the chandeliers at different heights and if symmetrically spaced would have been more pleasing in appearance.

To return to the stage lighting fixtures, they are very beautiful and expensive, but quite out of place in the Auditorium. In the first place, such a designed fixture can be most fully appreciated by daylight. The special brass design is scarcely visible when the fixture is lighted, and since the Auditorium is used primarily for evening entertainments, we consider such costly brass work as misplaced art. Even as a daylight ornament they are not close enough to the observer to be appreciated in detail. The proper place for such beautiful designs is in a building such as our Library, where they can be admired by the public during the day. They are intended primarily to be admired as pieces of art rather than to be used for efficient lighting fixtures, and this is best brought about by placing them where they can be exhibited as daylight ornaments at close range.

The lighting of the Auditorium corridor will next be discussed. Here the most beautiful part is the arches finished in white. Instead of installing a fixture which lights the arches and ceiling, one has been chosen which gives strictly downward distribution of light, leaving the ceiling and arches to be in darkness, unnoticed and unappreciated. The fixtures themselves are very beautiful, being made of heavy cast and spun brass.

The ceiling lights under the balcony are in clusters of unfrosted carbon lamps and from some positions are very trying to the eyes. These lamps should have at least been frosted and it is our intention to use tungsten lamps and

holophane hemispheres for these ceiling clusters hoping to give a much better distribution of light and also to give a more pleasing appearance to the system.

We have pointed out briefly some of the faults of the present lighting system from the standpoint of the artistic, the beautiful, and the appropriateness. Next, the comparative cost of the two systems will be considered. Here again we fell that a change in the kind of arrangement and the size of the lighting units will result in one of two things, namely, a saving in the cost of current consumption for the same intensity of illumination or an increase in the intensity for the same cost, or perhaps both.

The coming of the Tungsten lamp into commercial use has a great deal to do in making this possible. The Tungsten lamp uses about 1.25 watts per candle power, while the carbon filament lamp uses from 3 to 4 watts per candle power. The higher efficiency of the Tungsten lamp together with its longer life more than balances its higher first cost. Besides, the Tungsten gives a much whiter light than the carbon lamp, which is a decided advantage.

The question of the lighting of the Auditorium approach will be taken up if the time permits, and if possible some definite plan will be outlined although it may not be carried out at the present time.

It is our purpose in this Thesis to follow along the lines herein outlined, and if, after careful study and thorough investigation, we find that these changes can be

made, resulting in a more artistic, a more pleasing, harmonious whole, besides effecting a decrease in the operating cost, these changes will be made. Then if the University body and the surrounding town's people will recognize and even in a faint was show their appreciation of our efforts we will feel that the time given to this most delicate and difficult problem will have been well spent.

PROCEDURE

Measurement of power and intensity of illumination

The first thing to be done was to measure the power used by the present system of lighting, and next to measure the intensity of illumination at the various points in the Auditorium proper. Then after the new system is installed similar readings of the power and intensity of illumination will be taken and the results of the two systems tabulated for comparison.

For measuring the power, the following instruments were used:
Westinghouse Voltmeter #3332 with a range of 0-150
Westinghouse Ammeter #14030 " " " " 0--50
Hoyt Ammeter #19375 " " " " 0-3-10

At the branch switchboard it was possible to tap in on the different circuits; with the ammeter, and voltmeter and take readings of the power supplied to each circuit. To assure ourselves that no error was made in this work, the power required by the lamps was figured out from their factory rating. These results compared very favorably with the read-

ings as given by the instruments. The readings of current and voltage are given on pages 17 and 18 .

_ Description of Photometer _

The readings of the intensity of illumination were taken with a new type of photometer which we will describe here in a brief way. It is called the new Sharp-Millar Portable Universal Photometer, and is made by the Foote, Piersons & Co of New York. The body of the instrument is a hard wood box about two feet in length, having a hinged cover so that the entire interior is accessible. The movable part of the photometer is the comparison lamp, and not the photometric device. The lamp is mounted in a circular metal housing and is carried on a platform arranged to slide on a track lengthwise of the box. The scale from which the indications of the photometer are read consists of a translucent celluloid scale and is set in a longitudinal opening in the side of the box. In order to prevent external light from having access to the interior of the box this scale is covered by a long shutter which can be opened by means of the external knob. The elbow tube at the end of the box fits a friction tight collar fastened to the end of the box, and hence may be turned about an horizontal axis and set at any angle, which angle is indicated on a semicircular scale on the end of the box. In the elbow of the tube is fixed a reversible plate- one side being a diffusely reflecting surface used in measurements of candle power, and the other side a mirror used in connection with a

test plate on the end of the tube for measuring illumination. This latter setting is the one which was used in our work. The remarkable range of the instrument is from 0.004 foot candle to 2000 foot candles. When measuring the illumination in a room lighted by the incandescent lamps, it is advisable to operate the comparison lamp in the photometer box from the same circuit that supplies the lighting of the room. This precaution was regarded in our work, and besides this voltmeter readings were taken at the lamp so that if necessary the test lamp could be callibrated and the corrections made for the difference in voltages. The photograph on page 53 shows the general appearance of the photometer. With this photometer the intensity of the illumination was measured at the various points of the Auditorium both on the mainfloor and in the balcony. The accompanying drawings, pages 27 and 28 , show the points at which readings were taken,and the data, pages 19 and 20 shows the intensity of illumination in candle feet at these various points.

After the necessary changes have been made in the lighting system,readings of power consumed, and the intensity of illumination will be again taken. These results tabulated with those of the other system of lighting will give comparative results in power consumption and intensity of illumination.

The changes which we recommend in the lighting system can be outlined as follows:

(a) Altering the dome fixtures and changing the lights.

(b) Changing the stage fixtures and lights.

(c) Changing of lighting under the balcony and at the back of the balcony.

(d) Altering the corridor lighting.

(e) Installing proper lighting for the Auditorium approach.

The Dome Chandeliers and Lighting.

The dome chandeliers, eleven in number, are shown in the accompanying photograph, page 36 . The length of the suspending rods were twenty-seven feet. From the center of the brass sphere projecting horizontally were twenty-four brass arms, twelve of them being each twenty-one inches in length, the others being each ten inches in length. Each supports an eight candle power 110 volt bare carbon filament lamp. These fixtures appear like huge spiders hanging from the ceiling. The photograph on page 36 gives one a fair idea of their appearance. To avoid this appearance and to get the lamps out of the direct line of vision of the audience, the suspension rods will be shortened to fifteen feet, and in place of the twenty-four arms will be substituted six of a different design as suggested by the accompanying drawing, page 31 . Each arm will support a 60 watt frosted tip meridian tungsten lamp. From the suspension rod will

be drooped six brass chains to be fastened to the ends of the six arms. This will solve very satisfactorily the appearance of the chandeliers and the frosted tungstens will give a softer, more diffused lighting effect.

The placing of the dome and stage lights at a greater height will not, as many believe, diminish the intensity of illumination at any one point in the room. We often take the old rule that the intensity of light varies inversely as the square of the distance from a single light source, to hold true at all times when as a matter of fact where we have lights evenly distributed over-head, this rule does not apply. Take, for example, a large interior lighted by ceiling fixtures evenly distributed. A point four feet from the ceiling will receive a great deal of light from the lamps in its immediate vicinity, but due to the great angle it forms with the more distant lamps, little light from them will reach this small area. Again, suppose this point to be lowered to a distance of sixteen feet from the ceiling. Now light from many more lamps will fall upon this area and though the light from each is reduced the area will be fully as well lighted. It will not receive one-sixteenth as much light as is generally supposed. Due to the reflection of the light from the walls, the area in the latter position may be even better lighted than before. Hence we believe that to raise both the dome and stage fixtures will give as good illumination as before, and will in addition improve the appearance of the interior.

The Stage Fixtures and Lighting

The stage chandeliers, eight in number, were suspended from the arches by vertical brass rods thirty-four feet in length. The photograph on page 34 shows these fixtures. In each fixture were three 16 candle power carbon filament lamps. These fixtures will be removed and placed in the University Library. In their place will be substituted four six-foot pendant fixtures, suspended from the front arch above the stage. Each will consist of one, 100 watt frosted tip tungsten lamp, equipped with a twelve inch hollophane downward reflector. This will not only give the audience an unobstructed view of the painting , but will also give the painting a much better lighting.

The Balcony Lighting

The wall lights under and at the back of the balcony are properly located, but the twenty watt bare tungsten lamps will be substituted for the 16 C.P. carbons to maintain a uniform color of lighting. Aside from this no changes were considered necessary.

The Corridor Fixtures and Lighting

The corridor ceiling fixtures, five in number, are very beautiful and ornamental as shown by the photograph on page 37. There are tow things, however, which are decidedly bad in this fixture.

1. The lights are all placed on the under side,

leaving the upper part of the fixture as well as the arches and ceiling of the corridor in shadows and darkness.

3. The bulbs are unfrosted, and this fails to bring out the cluster effect, which should be produced in these fixtures, as daylight ornaments. The frosted bulbs substituted will produce this cluster effect.

The first difficulty was overcome by cutting four outlets equally spaced in each chandelier, and at the base of the upper curve. In these were mounted sixteen C.P. carbon filament lamps. This gave the desired effect of lighting for the archs, ceiling, and the chandelier itself.

The frosted bulbs as substituted for the plain gave a softer light, and a more pleasing cluster effect by day.

Lighting of Auditorium Approach

The question of installing ornamental lighting posts on the butresses of the Auditorium approach was taken up and considered. (see photograph, page 32) A letter was written to the architect, Mr. C. H. Blackall of Boston, telling him of our plans of installing concrete lighting posts at the entrance and asking him whether or not he had any suggestions to offer. In his letter, in reply, he stated that for such a place he considered concrete posts out of place if resting on a limestone base. Enclosed was a blue print of an ornamental iron post which he had designed for the butresses of the Auditorium. He added that the character of the design as shown by the blue print was the one usually followed for such a place, but it is a decorative feature rather than

strictly practical as regards illumination.

Owing to the lack of funds for the work it was impossible to take any steps toward purchasing these ornamental posts at the present time, but we have placed the matter before several prominent members of the 1910 class who will make every effort to have this design worked out for their class memorial. The blue print sent by Mr. Blackall is included here, page 31 , with the thought that it will aid materially in the selection of some appropriate design. We feel grateful to Mr. Blackall for his interest and assistance in this matter and hope that before long his design will be worked out and the ornamental posts installed.

DESCRIPTION OF SWITCHBOARDS

The two switchboards, which control the main lighting circuits, are located in a small room overlooking the stage. This room is in the southeast corner of the Auditorium at the end of the corridor leading from the balcony. Each board is a one piece, brown marble slab supported by angle irons. A simplified drawing of these boards is shown on pages 29and 30 . Board B is on the east and board A on the south side of the room. The two three-pole single throw switches located at the top and bottom of each board throws the power onto the busses and from there the lighting circuits are closed through the cartridge fuses by double-pole single throw switches. These switches are numbered as shown and the number of lights they control is given. The notation given in the diagrams is that used in recording the data.

DISCUSSION OF DATA-

The factory rating of the carbon lamps was taken and the power consumption computed, assuming 3.5 watts per candle power (at 110 volts.) This was done as a means of checking the measurements of power consumption at the switchboards. The actual power consumed by the lamps, is less than that computed from the factory rating. This is due to the fact that instead of operating the lamps at 110 volts, they were operated at about 103 to 105 volts. However, the data checks sufficiently close to assure us that our readings were fairly accurate.

Readings of the voltage taken at no load to full load currents show a variation of from 115 to 103 volts respectively, a difference of 12 volts. This is a variation of 10% of full load voltage, and is not considered satisfactory operation. The conditions under which the measurements were taken were not as favorable as the conditions under which the lamps ordinarily operate, for usually the switchboard attendant at the power plant maintains a uniform voltage. This was hardly possible when our measurements were taken, due to the large and sudden changes in the test load.

POWER USED BY THE CARBON LAMPS BEFORE THE CHANGES

Switchboard "A"

Switch	No. of Lamps	Size	Computed	By Measurement		Watts
No.		C. P.	Watts	Volts	Amperes	
1	12	16	672	109	5.3	577.7
2	8	16	448	109	3.5	378.0
3	12	16	672	109	5.4	588.6
4	8	16	448	111	3.6	399.6
6	10	16	560	107	4.5	481.5
7	14	16	783	106	5.9	625.4
8	14	16	783	104	5.6	582.9
9	12	16	672	110	5.5	605.0
10	12	16	672	109	5.4	588.6
Total	102		5699		44.7	4827.3

BOARD "B"----

Switch No	No. of Lamps	Size C. P.	Computed Watts	By measurement Volts	Amperes	Watts
1	96	8	2680	103	28.5	2935
2	12	16	672	107	5.0	535
3	30	16	1680	104	12.0	1248
4				105		468
5	8	16	448	104	4.5	4680
6	72	8	2000	103	18.5	1920
7	8	16	448	107	3.5	375
8	96	8	2680	103	28.0	2900
9	12	16	672	107	5.2	555
Total	186		11280		100.7	10936

ILLUMINATION OF THE MAIN FLOOR WITH THE CARBON LAMPS

Position of Photometer		Voltage	Reading in candle feet		Average
Number	Seat		1st	2d	
1 a	260	105.0	.34	.36	.350
2 a	31	105.0	.36	.37	.365
3 a	177	103.0	.25	.25	.250
4 a	31	105.0	.37	.35	.360
5 a	250	105.0	.34	.33	.335
1 b	255	105.0	.30	.30	.300
2 b	218	104.0	.31	.32	.315
3 b	120	104.0	.38	.39	.385
4 b		105.0	.29	.32	.305
5 b	255	105.0	.32	.29	.305
2 c	248	103.5	.40	.40	.400
3 c	31	105.0	.38	.38	.380
4 c	249	105.0	.38	.36	.370
5 a'	99	105.0	.130	.127	.128

STAGE READINGS

R	103.0	.45	.42	.435
S	103.5	.39	.38	.385
T	102.0	.40	.40	.400

ILLUMINATION OF THE GALLERY WITH CARBON LAMPS.

Position of Photometer		Voltage	Reading in candle feet		Average
Number	Seat		1st	2d	
1 a	25	104.0	.196	.205	.200
2 a	13	105.0	.440	.43	.435
3 a	14	109.0	.34	.34	.340
4 a	12	107.0	.38	.38	.380
5 a	13	110.0	.34	.34	.340
6 a	14	103.5	.40	.42	.410
7 a	13	103.0	.16	.17	.165
1 b	76	103.5	.32	.31	.315
2 b	77	104.0	.40	.40	.400
3 b	90	108.5	.32	.32	.320
4 b	77	107.0	.35	.36	.355
5 b	77	110.0	.36	.37	.365
6 b	90	104.0	.33	.37	.350
7 b	62	104.0	.29	.29	.290

CONCLUSION-

The changing of the lights and lighting fixtures at the Auditorium as outlined and discussed in this thesis are not at this time completed. This is due partly to the fact that these changes were not approved until late in the semester, but more especially to the fact that the order for tungsten lamps could not be shipped for some time. The changes to be made are clearly outlined in this thesis, and as soon as the fixtures and lamps are received the work of installation will be finished.

The question of ornamental lighting posts for the Auditorium approach has been discussed and arrangements made which will undoubtedly result in their installation within a year.

The corridor fixtures have been remodeled according to the plan herein given, and the result is even more pleasing than we had expected. It may be that some of the things we have planned will be changed slightly due to unforseen difficulties arising but we believe that in a general way our plans will be followed.

We regret that we were not able to see these changes completed and that we could not take the readings of power consumption and intensity of illumination of the new system. Space will be provided in the thesis where this data can be recorded when taken, and although this is not the most important part of the thesis, it will be nevertheless interesting and will show the superiority of the new metal filament lamps.

In closing, we believe that it is not out of place to mention that we owe a great deal to Professor Morgan Brooks and Professor James White, for their valuable suggestions and assistance in this problem of the illumination of the University of Illinois Auditorium.

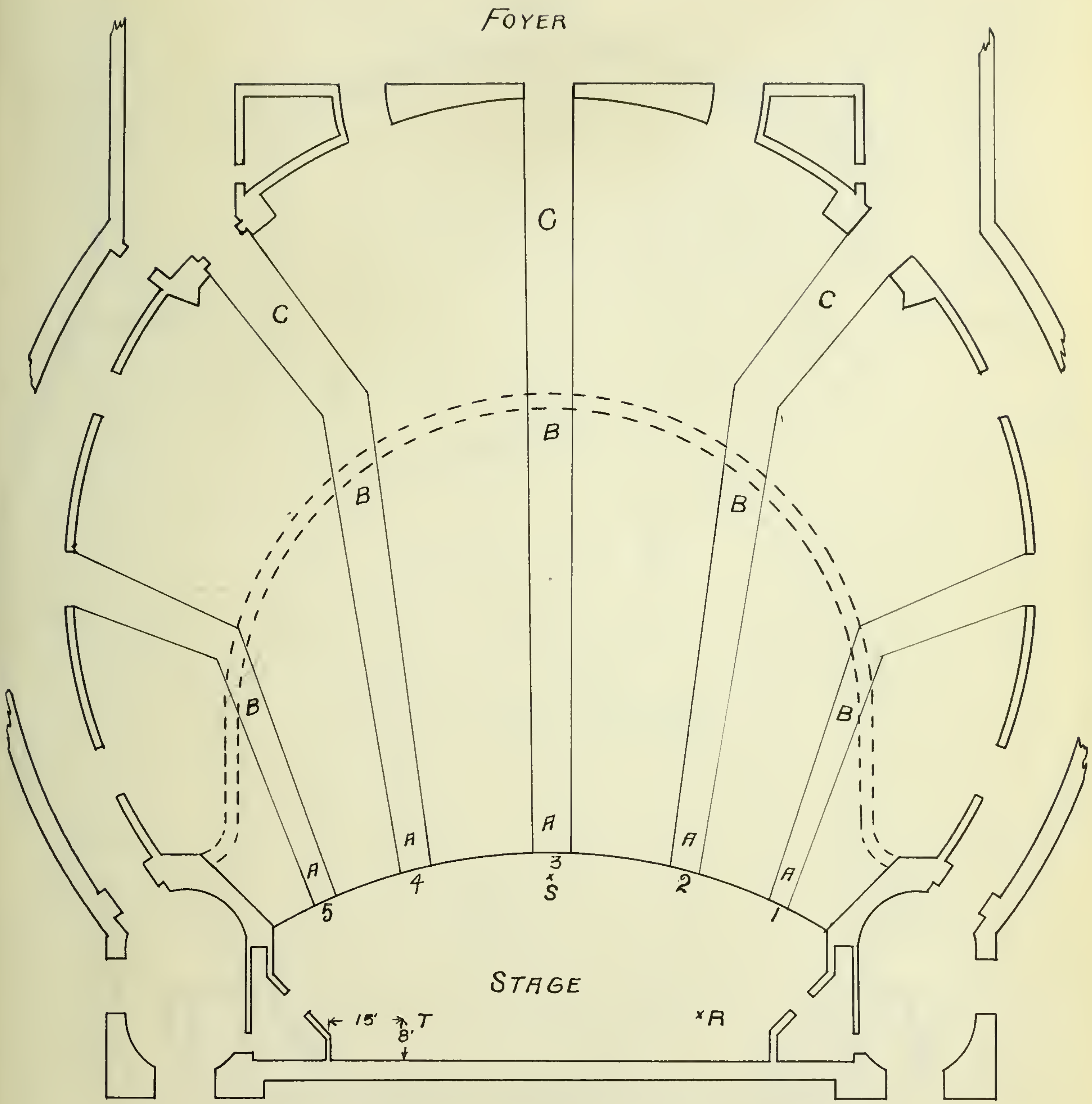


DIAGRAM OF THE MAIN FLOOR

SHOWING POSITIONS OF THE ILLUMINOMETER

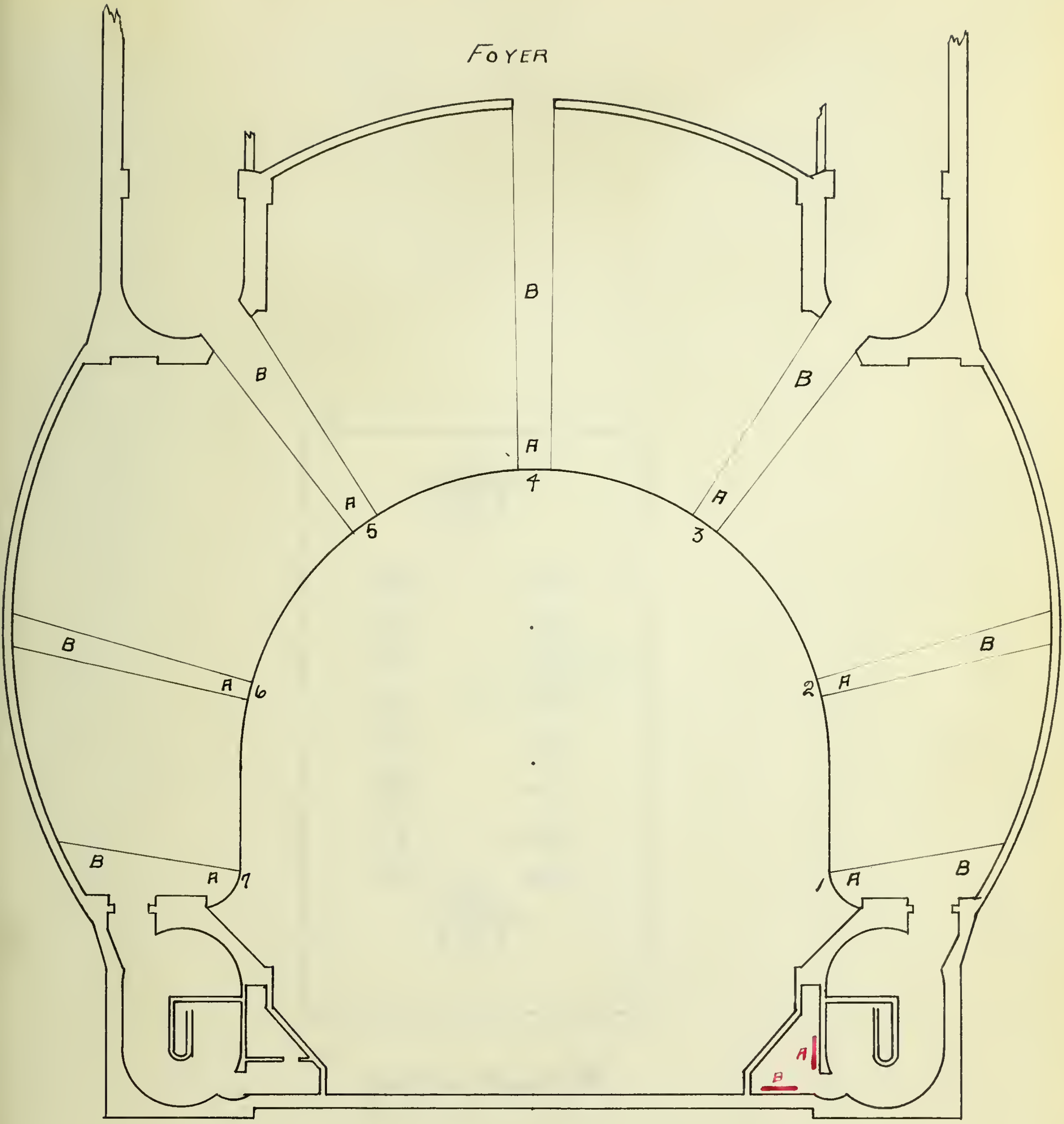
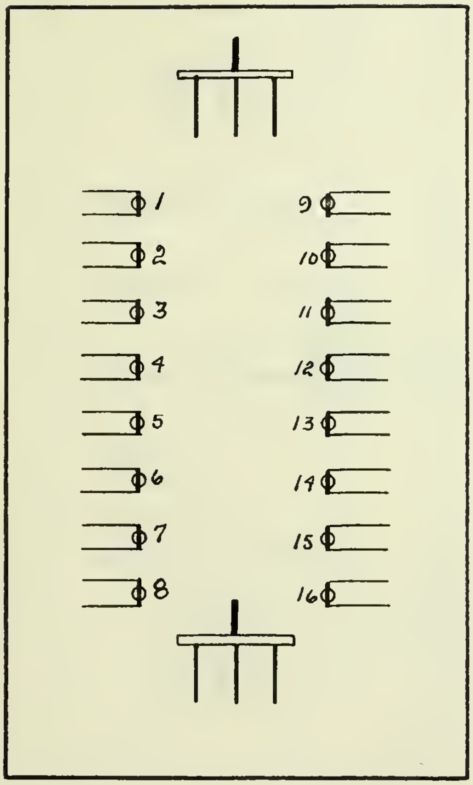
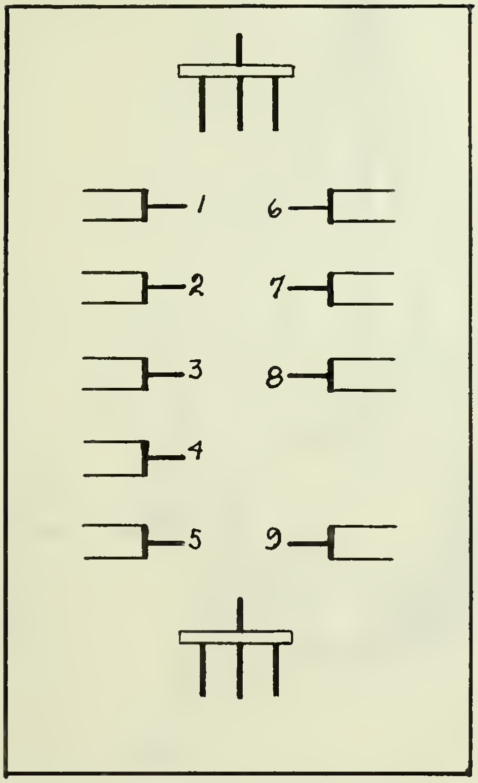


DIAGRAM OF THE GALLERY.

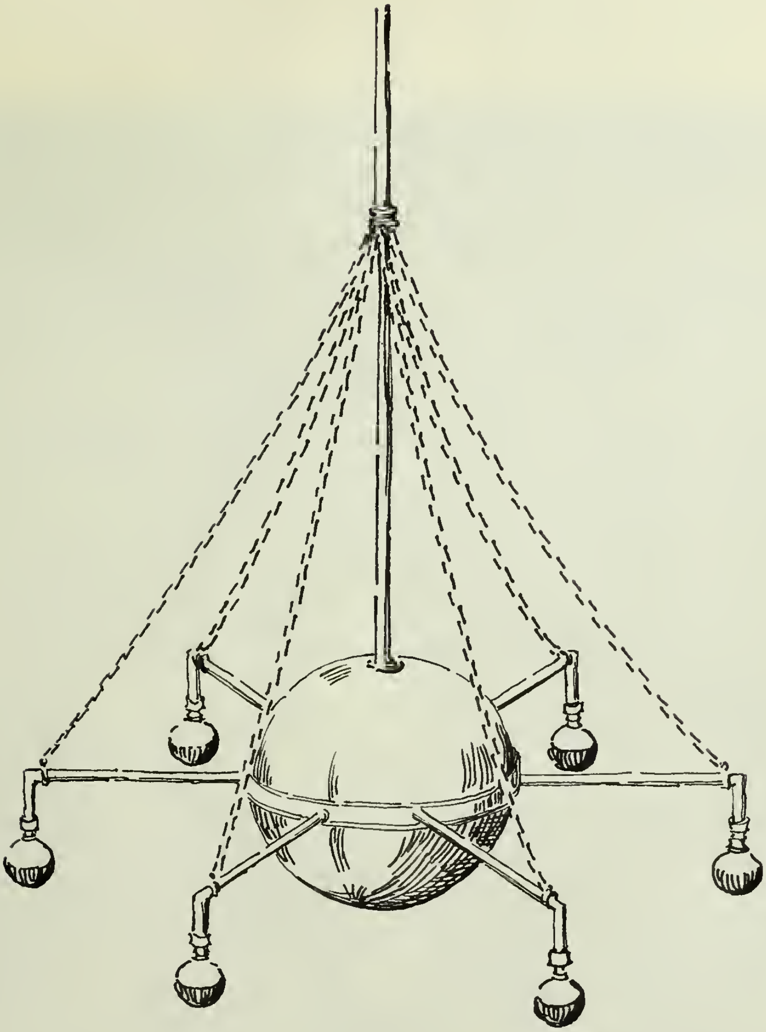
SHOWING POSITIONS OF THE ILLUMINOMETER.



Switch Board "A."

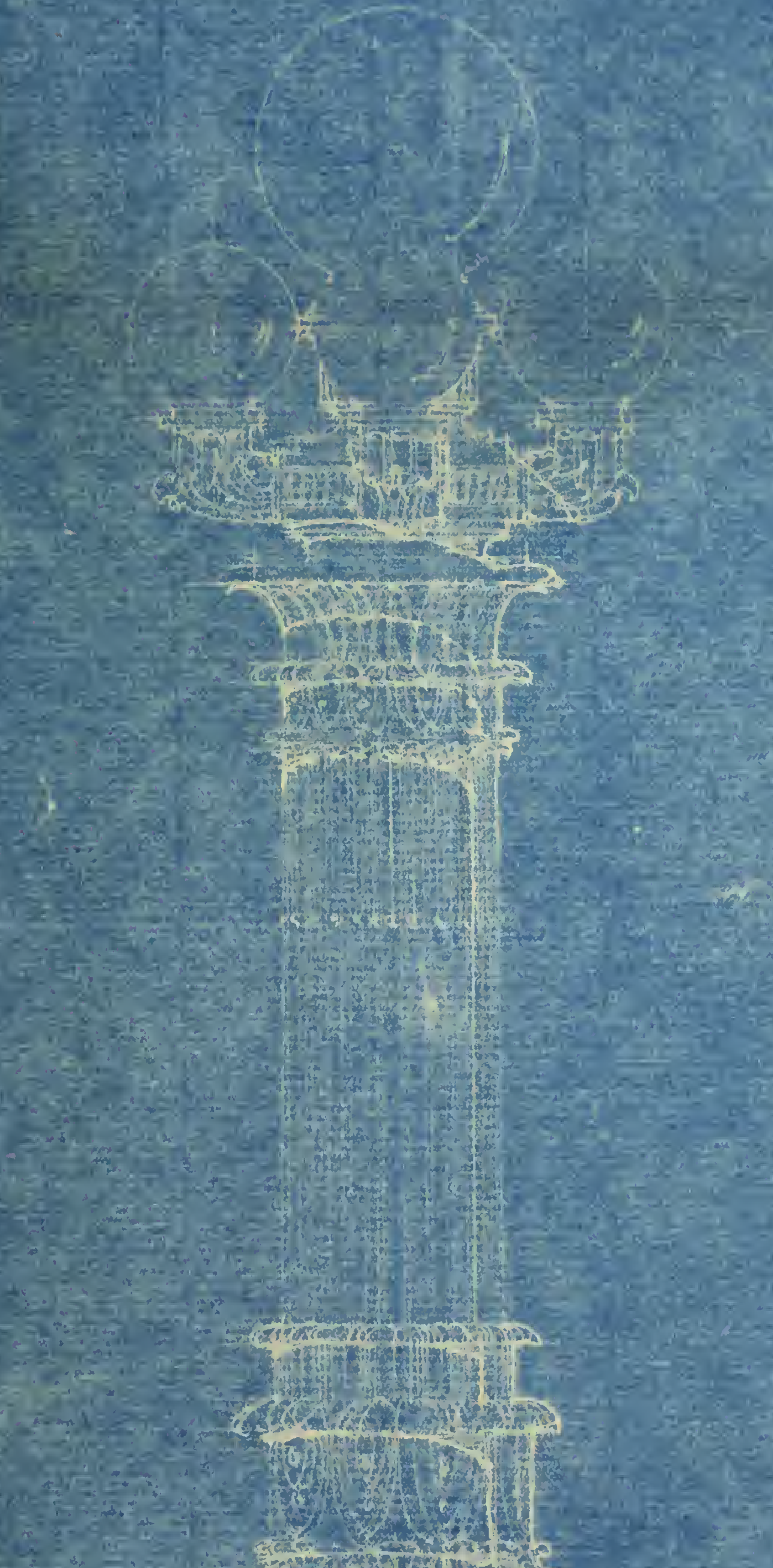


Switch Board "B"

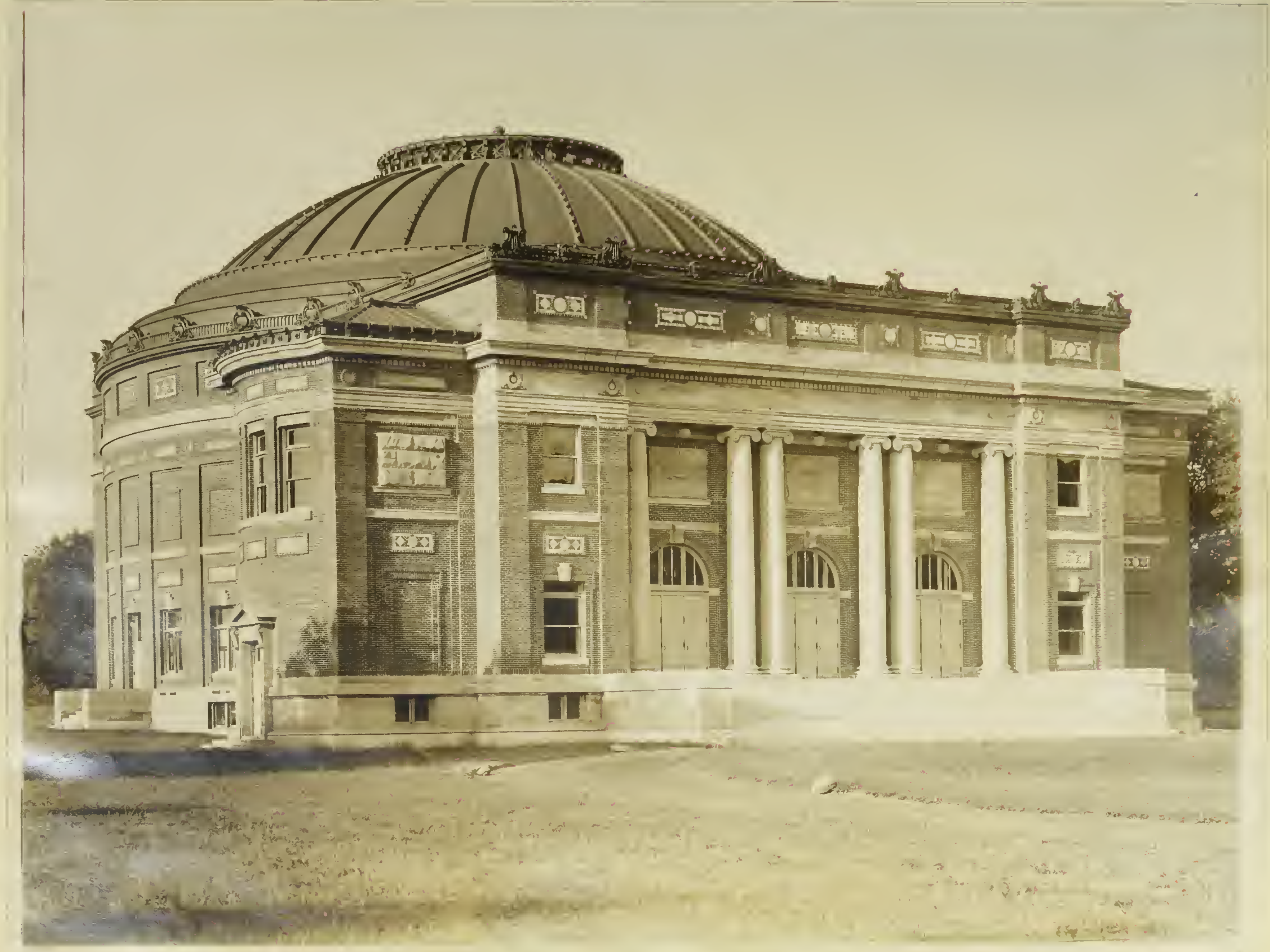


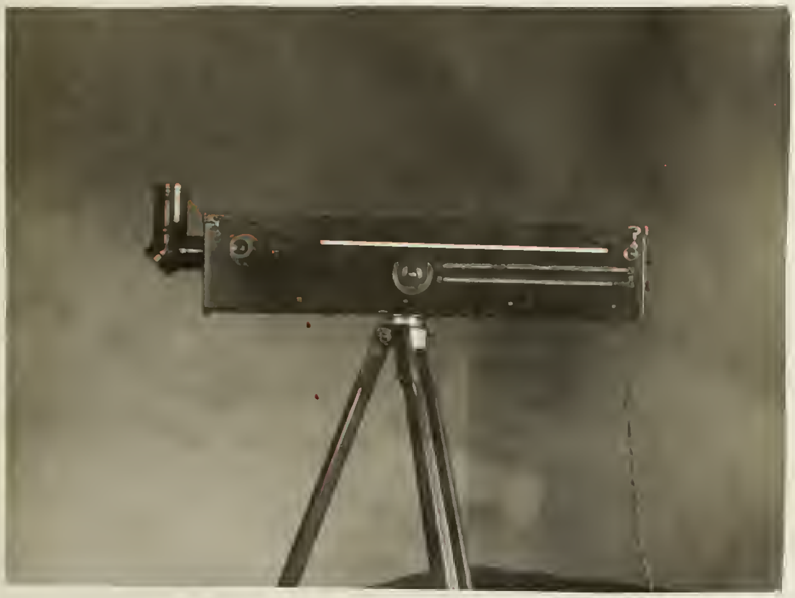
DOME-CHANDELIER. NEW DESIGN.

TYPE "H"

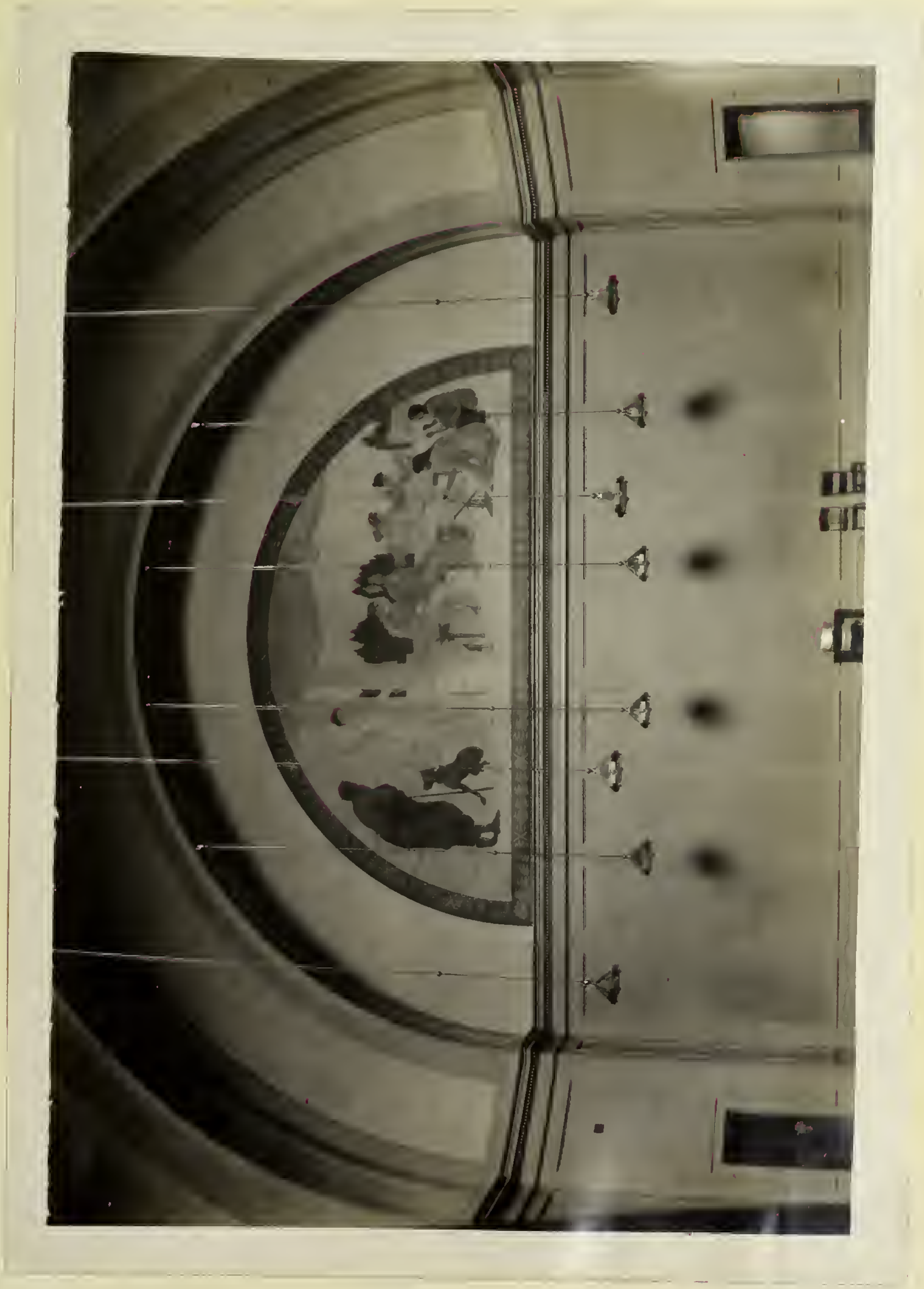


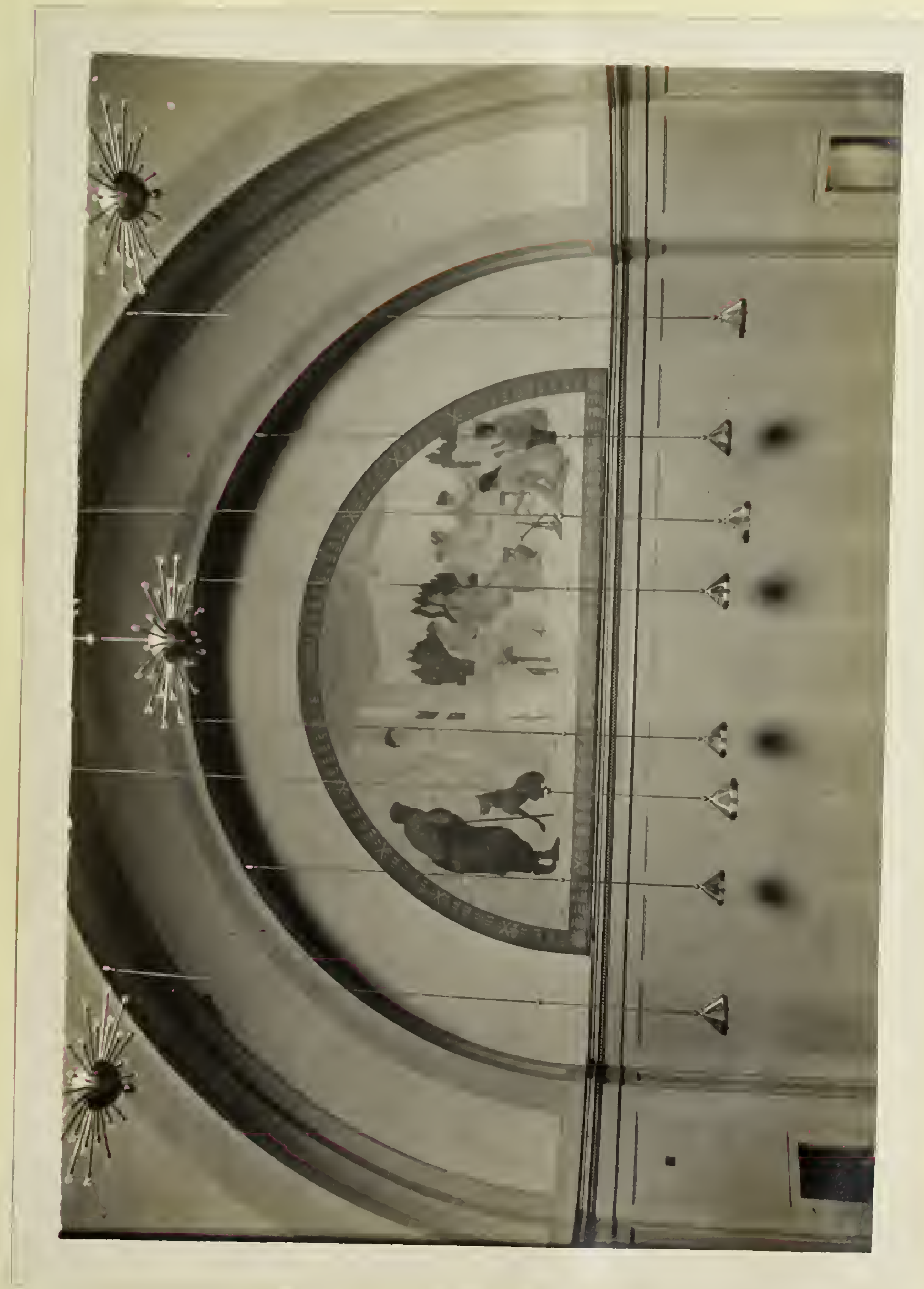
ONE INCH SCALE

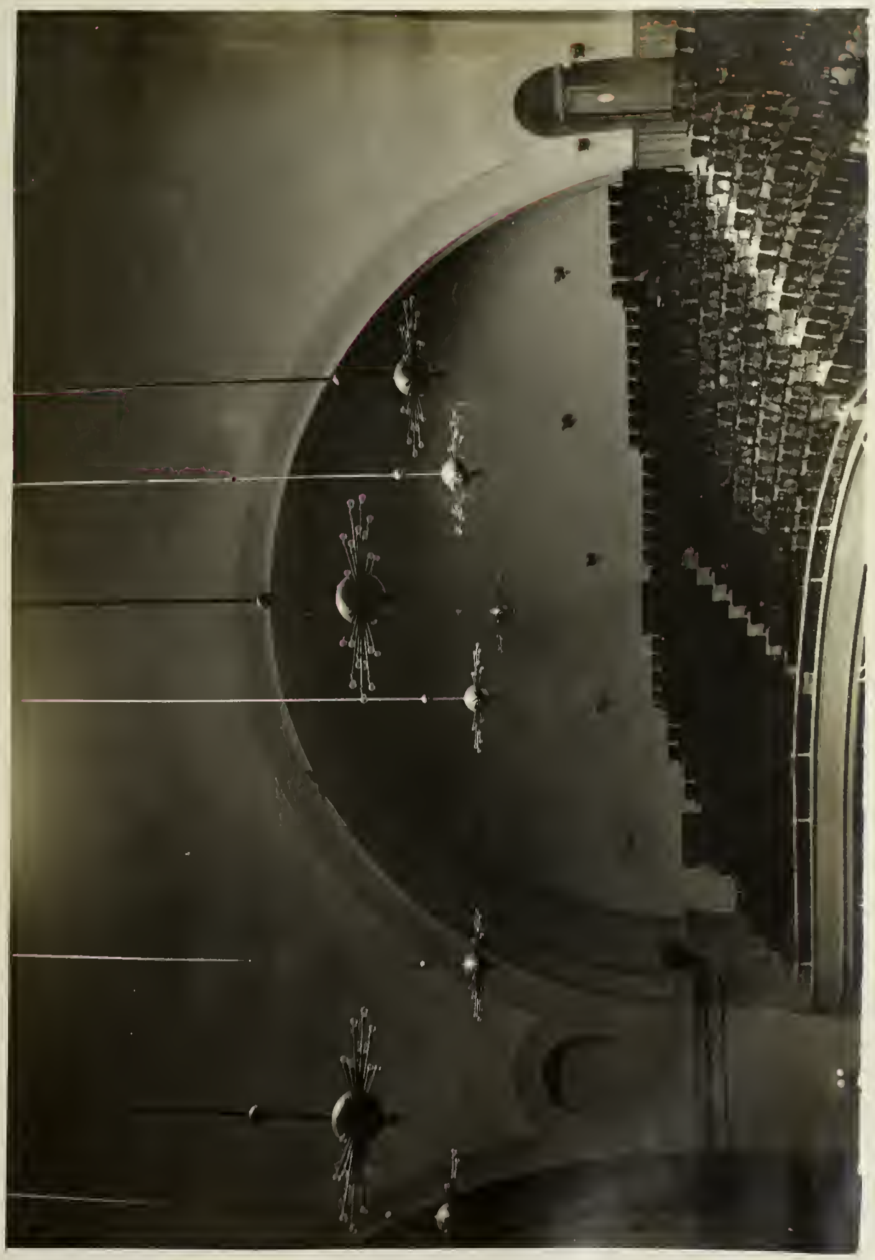




SHARP-MILLAR PHOTOMETER







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